ASSESSMENT TECHNIQUES FOR REEF HABITATS ON THE SOUTHEAST UNITED STATES CONTINENTAL SHELF

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Reef fisheries off the southeast United States extend from Cape Hatteras, North Carolina to Key West, Florida, around the Gulf of Mexico to Mexico, and on shelf areas throughout the Caribbean. Types of reef habitat are numerous, the overall fauna is complex, and the intensity and kinds of fishing vary. Together, reef resources pose complex assessment problems. Assessment and monitoring of reef habitats are needed because there is substantial commercial and recreational harvest of reef fishes and management is required under the Magnuson Fishery Conservation and Management Act.

Of the major types of natural reef systems on the southeast United States continental shelf, probably most important to fisheries are the "hard bottom" reefs which are scattered at depths of 20-200m over the shelf from Cape Hatteras, North Carolina to Ft. Pierce, Florida, and throughout the Gulf of Mexico. Shelf width varies greatly by region: wide (to 160 km) off the Carolinas, Georgia, and the Gulf of Mexico to narrow off South Florida and much of the Caribbean. "Hard bottom" reefs usually are associated with outcropped sedimentary rocks. Relief ranges up to several meters, and the bottom is richly overgrown with macrobenthos (sponges, sea fans, soft and diminutive hard corals, etc.). A second reef type is the hermatypic coral reef (principally off South Florida), which for discussion of assessment we include with "hard bottom" reefs. The third category includes the deep shelf edge and shelf break reefs which occur in a narrow band from about 100-250m throughout the region (see Barans this volume).

Fishing practices vary little with region, but several gears are employed depending on the habitat and target species. Most of the commercial catch is from hook and line fishing with power reels. Bottom longlines on deep reefs take grouper and tilefish. Roller trawl gear and "high rise" trawls were occasionally used in the South Atlantic Bight north of Cape Canaveral. Their use was banned in the EEZ with approval of Amendment 1 of the Snapper-Grouper Fishery Management Plan in January 1989. Traps catch primarily black sea bass in the EEZ of the South Atlantic Bight and mixed reef species off Florida. Recreational catch with hook and line comes from private vessels, charter boats, and headboats (Huntsman 1976). There are about 90 active headboats in each the South Atlantic and Gulf of Mexico.

Background data on the history of exploitation of the South Atlantic shelf reef resources are sparse and difficult to interpret. North of Georgia, the commercial snapper-grouper fishery is modern and began in earnest in the 1970's, but early catch records did not identify species caught. Recreational reef fishing dates to the 1920's and had become substantial by the early 1960's but no records of catch exist. Thus, fishery-dependent data were not available for stock assessment and management purposes. Likewise fishery-independent data were lacking. Amounts of habitats, depth distribution, and abundance of various dominant reef fishes were not well known. Although "new rocks" or fishing sites are occasionally located, the system is highly exploited and many species are probably subjected to, at least, growth overfishing.

At the Beaufort Laboratory reef fish research efforts began in 1972 and were oriented toward describing life histories, especially growth, of South Atlantic and Gulf of Mexico reef species. Also, a headboat survey was initiated to develop long term data sets on catch and size distribution of reef fishes. Region wide sampling for size composition of commercially harvested reef fishes began in 1984 as the Trip Intercept Program (TIP). Our fishery-independent assessment efforts on reef fishes have concentrated on:

1) developing and testing methods for monitoring resources,

2) delineating and estimating the amount of available habitat,

3) defining fish community dominants and their biology, and

4) developing and testing methods for population estimation.

Mark-Recapture and Point Estimates of Fish Abundance

Early studies included tagging and SCUBA observation to ascertain fish movements and estimates of population size (Parker 1990). We tagged 4,150 reef fish off the Carolinas and Florida between 1972-75. Our laboratory retention studies (up to 6 months) revealed 75% loss rate for Floy (FT-2) dart tags applied to red porgy and no loss of Petersen disk tags in red porgy and spottail pinfish. Regrettably, about 75% of released fish in the field study carried dart tags. Tag returns (n=29) indicated little movement even after 2 years at large, and most recaptures were within 6 km of the release site. In 1975-77 we focused on a single reef off North Carolina to estimate local population size by mark-recapture procedures. Monthly point counts by divers allowed comparison of visual and indirect techniques. We tagged 2,736 fish (Petersen disk tags), representing 40 species and got 121 returns (4.4%). The recapture of several tagged black sea bass by hook and line as often as 3 times over this study period suggests high survival of released fish and good tag retention. Again, tagged fish moved little. Population estimates for black sea bass via Schnabel and Schumacher-Eschmeyer methods were identical. Estimates resulting from visual methods (SCUBA) varied considerably from tagging results. Water clarity and habitat heterogeneity both affected results profoundly. Visual estimates were 33 times greater than those of mark-recapture. We believe tagging gives a better measure of local reef abundance than visual counts as applied in this study for high density species such as black sea bass. Wenner et al. (1986) successfully used the Petersen mark-recapture technique for black sea bass population estimates at two patch reefs off South Carolina. Given that most reef species are far less abundant, we believe they may be more reliably censused by visual methods.

We conclude that for long term monitoring and assessment of most reef species tag-recapture, trap CPUE, hook and line CPUE, etc. do not provide efficient, reliable assessments even on a small scale (high density species, like black sea bass are the exception). Variability of trap, and hook and line catches was so great that surveys based on these methods are virtually impossible. The immense sample sizes required would greatly exceed even liberal budget prospects. We have since focused our fishery-independent studies of reef resources on visual estimation techniques.

Estimates of Reef Habitat

A first approximation of potential reef fish biomass, independent of catch-effort data, is possible by multiplying the amount of reef habitat (area) by the mean fish biomass per unit of reef area. In 1975 published estimates were not available for the amount of reef habitat and mean fish biomass in the South Atlantic Bight. Subsequently Parker et al. (1983) estimated the amount of reef area on the shelf between the 27-101m isobaths, Cape Hatteras, North Carolina to Cape Canaveral, Florida and between the 18-91m isobaths, Key West, Florida to the Mexican border. Since this procedure is a necessary first step toward assessing reef resources and is applicable to other shelf areas, highlights of that study follow.

The amount of reef habitat (rock, coral and sponge) was estimated from observations with a closed-circuit underwater television (CCUTV) system which was lowered from the OREGON II. Video monitoring and taping were conducted while the ship and camera system were drifting. An observer recorded the type of habitat seen during the initial view of a meter quadrat of the sea floor. The substrate was classified during the initial view of the sea floor, but up to 15 minutes of drift time were spent at some stations. The bottom was classified either as reef or non-reef at randomly selected stations within depth/area strata. If reef habitat, the station was further classified by relief less than or greater than 1 m. If non-reef, it was classified as vegetated or bare sand, sand/shell or mud. From the proportion of reef to non-reef points in the area sampled and from the known area of each stratum, the amount of reef was estimated.

Considerable reef habitat exists out to 100m depth in the South Atlantic Bight and Gulf of Mexico (over 57,000 km² or 22.8% of total area) but very little is over 1 m in relief (4,143 km² or 1.7% of total area). The remainder of the survey area was classified as sand/shell (about 50%), mud (25%) and vegetated (3.6%, includes SW Florida inshore areas). The shelf from Cape Hatteras to Cape Canaveral contains an estimated 9,443 km² of reef habitat (Table 1). Considerable variation in amount of reef existed among locations. Rock, coral, and sponge were patchy in all strata. Reef habitat occurred at 24% of the stations between Cape Hatteras and Cape Canaveral. This compares favorably with data of Miller and Richards (1979), who found reef fish at 18.9% of 5,300 trawl stations made during cruises by the R/V SILVER BAY. The similarity of these results suggests that trawling records might be useful for estimating the amount of reef habitat. The remaining deeper and unsurveyed area (101-183m) is small relative to the shallower, surveyed area, but it contains high relief habitat and probably contributes significantly to total reef fish biomass, particularly to that of deepwater groupers and golden tilefish.

Table 1. Estimates of percentage and area of reef habitat in South Atlantic (95% confidence limits in parentheses). Survey Strata (27-101 m depth). (from Parker et al. 1983)

		Cape Hatteras - Cape Fear	Cape Fear - Cape Canaveral
Area in Stratum (km²)		14,486	24,826
Area Reef Habitat (km²)	Total Reef >1m Relief	2.040 (1.027 - 3.500) 0.204 (12 - 1.91)	7.403 (4.608 - 10.745) 1.743 (504 - 4.208)
% Reef Habitat	Total Reef >1m Relief	14.1 (7.1 - 24.3) 1.4 (0.1 - 7.5)	29.8 (18.6 - 43.3) 7.0 (2.0 - 17.0)

For cataloging shelf bottom types and estimating the amount of reef habitat the straightforward, randomized procedure with an underwater TV worked well and produced credible results. Similar surveys should be undertaken for the 101-183 m shelf area to complete the habitat estimate. Technical difficulties with CCUTV such as sea state, turbidity, currents, and instrument reliability exist, but they often can be accommodated for habitat characterization studies.

Visual Surveys of Species Composition and Abundance

Photographic methods including TV or RUFUS allow a permanent record of extended observations on fish behavior and habitat association, but they are compromised by dim lighting, small depth of field (turbidity = visibility), narrow angle of view, difficulty in tracking target objects, and fish reaction to the gear. Surface deployed cameras requiring umbilical power have additional problems related to ship stability and control of camera view. Acoustic monitoring (Barans and Holliday 1983) has many of the same problems, in addition to validation of the technique.

We opted to use diver counts via submersible and SCUBA techniques for enumeration of fish. We have used submersibles on deep water reefs off North Carolina to:

(1) estimate standing stocks to supplement our yield estimates of reef fishes important to recreational and commercial fisheries

(2) examine the effect of submersibles on fish behavior

(3) estimate species composition and relative abundance, and

(4) observe behavior and habitat utilization on reefs below SCUBA depths (Parker and Ross 1986).

Using the JOHNSON SEA-LINK II (10 dives) and NEKTON GAMMA (7 dives) for a total dive time of about 23 hrs, we examined 13 reefs at depths of 23-152m in Onslow, Raleigh, and Long Bays, North Carolina. Transect distances and horizontal visibility were measured to relate numbers of fish to units of area. Surface support ships provided LORAN C measures of transect length and position. To measure visibility the JOHNSON SEA-LINK II, before each transect, would retreat from a secchi disk placed on the bottom until reaching fade-out distance. The submersible then followed a straight compass course across a reef while the forward observer recorded on tape and film the habitat type, fish behavior, species composition, and relative abundance of all species. From the starboard porthole, the aft observer simultaneously counted recreationally and commercially important fishes (Huntsman 1976) within his view, 90° to the transect path. Using horizontal visibility and distance traveled, a rectangular survey area was calculated. In previous SCUBA experiments Parker observed that fishes faded from view in the last quarter of a diver's secchi visibility range. Thus, for expansion of fish numbers the observation area was reduced by 25% to account for the reduced zone of fish detectability. When using the NEKTON GAMMA, a single observer had to perform all scientific operations and observations.

On two occasions observations from a submersible were matched with counts by a SCUBA team to determine:

(1) if submersibles altered behavior of reef fishes beyond that caused by SCUBA divers, and

(2) if estimates of abundance of important reef fishes from submersibles can be compared to those made by divers. In the first test divers counted fishes and observed fish behavior in a 360° area during passage of the JOHNSON SEA-LINK II at two locations along a 180m transect in 27-29m depth (Fig. 1). Lateral visibility yielded a 30m diameter field of view. Divers thus had a field of 707m^2 for point counts and the submersible had a 450m^2 rectangular survey area. Composition and abundance of reef fishes important in the recreational and commercial catches were determined. As the submersible cruised the transect, the aft observer counted fishes on the starboard side between buoys. On a second occasion point counts were done by SCUBA divers 15 min after passage of the submersible.

Comparing observations made by divers to those from submersibles, we learned that fish generally ignored both SCUBA divers and the

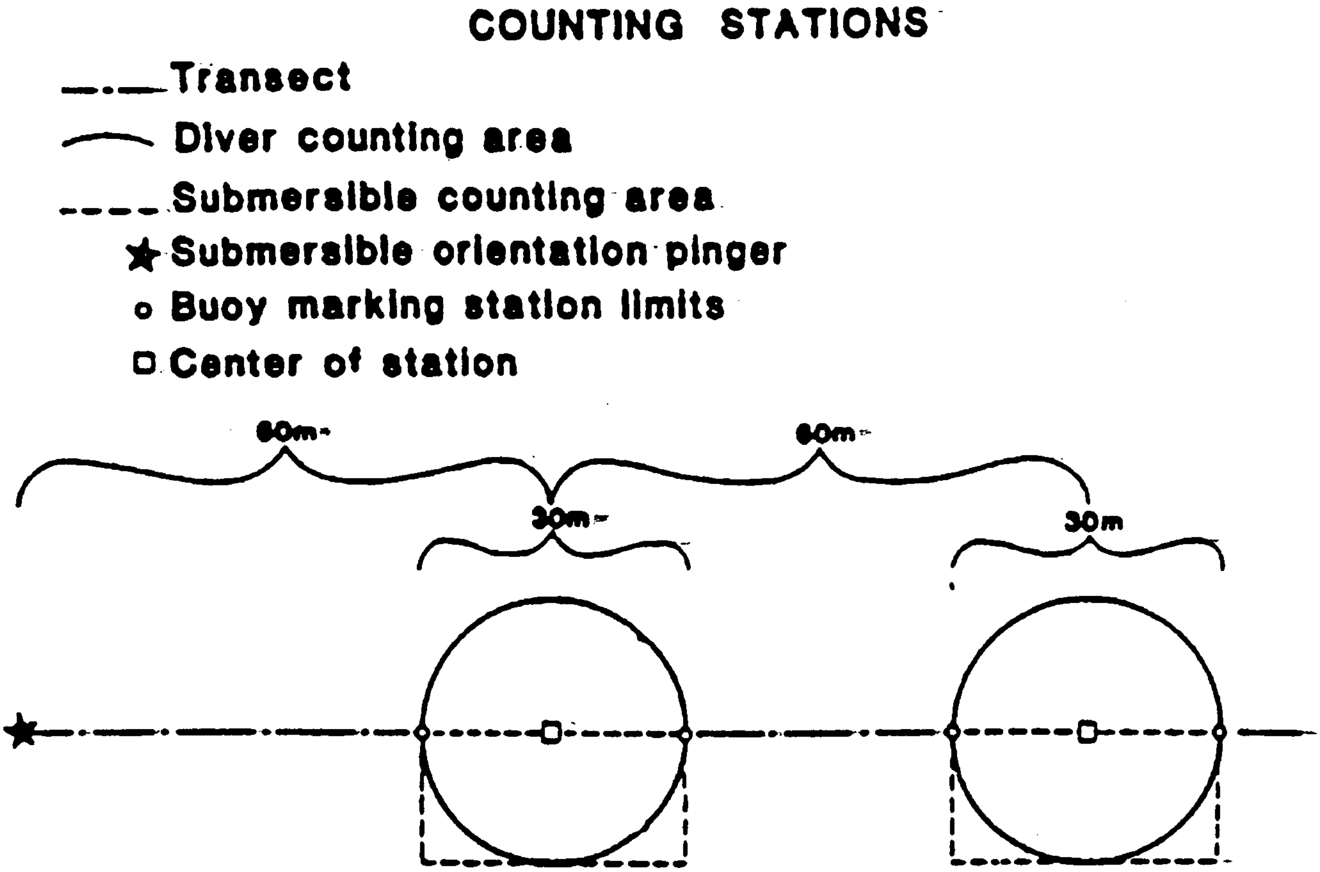

Figure 1. Schematic diagram of submersible and SCUBA diver fish counting. (Parker & Ross, 1986)

submersible. Fish counts of species important in the recreational and commercial fisheries were comparable when made simultaneously but when the submersible covered more area, more of the large, less abundant species were recorded. Conversely, the SCUBA team was more mobile in a small area and had a wider field of view, so it could better observe and identify small, cryptic species.

From transect data we derived biological and community features important for future designs of submersible and SCUBA surveys in the South Atlantic Bight. Some important species were widely distributed while others were more restricted to selected depth strata. Reef habitats (stations) contained significantly different numbers of species. The number of species and abundance were strongly correlated with vertical relief of the reef substrate in all depth strata and the mid-depths stratum (52-98m) contained the greatest number of species. The average number of recreationally and commercially important fish per hectare was 61 individuals over sand and 774 individuals over reef. Although only 7% of the fish counted occurred over sand bottom, up to 33% of the transect time was over sand habitat. Noteworthy also, were occasional sand covered ridges up to 20m high near reefs off the Carolinas. Some species previously thought to be tightly associated with reefs were actually seen rooting in sandy areas 10m or more away from the reef (red porgy, silk snapper, and snowy grouper).

The next steps in development of assessment procedures are unclear. We have been successful in counting/estimating selected species densities on reefs, but submersible and diver values need to be standardized. We need to measure the reliability of diver counts and how they vary among divers and as a function of the environment. Based on a field study at Looe Key, Florida, Witzig (personal communication)[1] examined many of the factors affecting the detection of objects underwater (size, coloration, number per area, habitat complexity, and physical characteristics of the water column). From this study he evaluated transect and point count methodologies used in estimating fish population abundance and determined the accuracy of visual estimates of population density. Quantification techniques for defining observer efficiency will allow calibration among divers, and in the future, transect surveys may be more comparable.

Conclusions

Our experiences reaffirm the belief that biologist can not effectively catch fish with unbiased gear or with uniform angler/hook efficiency. Hook and line, longline, traps, and trawl are fraught with application variability to such a degree that their use as long term monitoring techniques on shelf areas of the southeast United States is questionable. Chemicals and explosives are effective but generally unusable because they destroy habitat. Submersibles, TV, and SCUBA techniques offer proven ways to assess shelf habitat type, document species assemblages, and quantify abundance of dominant (important) resources. Each is useful over a selected depth range, and while equipment may be expensive on a daily basis, these visual estimates are probably less expensive than the more traditional hook and line, trap, and trawl approaches. Advances in SCUBA survey techniques such as in the "Bohnsack bounce" (see Bohnsack this volume) and Witzig's distance corrections lend even more credibility to their use as long term monitoring and assessment techniques.

We recommend that SEAMAP encourage completion of the TV survey for quantification of habitat in the 101-183m zone and that submersible techniques be used to complete the reef fish assessments needed to estimate yield potential in the South Atlantic Bight and Gulf of Mexico.

Footnote: John F. Witzig, NMFS, Fishery Statistics Division, 1335 East-West Highway 8313, Silver Spring, MD 20910. Ph.D. dissertation entitled Visual Assessment of Reeffish Communities, North Carolina State University, Zoology Department.

References

Barans, C. A., and D. V. Holliday. 1983. A practical technique for assessing some snapper/grouper stocks. Bull. Mar. Sci. 33:176-181.

Huntsman, G. R. 1976. Offshore headboat fishing in North Carolina and South Carolina. U.S. Natl. Mar. Fish. Serv., Mar. Fish. Rev. 38(3):13-23.

Miller, G. C., and W. J. Richards. 1979. Reef fish habitat, faunal assemblages, and factors determining distributions in the South Atlantic Bight. Proc. Gulf Caribb. Fish. Inst. 32:114-130.

Parker, R. O., Jr. 1990. Tagging studies and diver observations of fish populations on live-bottom reefs of the U.S. southeastern coast. Bull. Mar. Sci. 46:749-760.

Parker, R. O., Jr., and S. W. Ross. 1986. Observing reef fishes from submersibles off North Carolina. Northeast Gulf Sci. 8:31-49.

Parker, R. O., Jr., D. R. Colby, and T. D. Willis. 1983. Estimated amount of reef habitat on a portion of the U.S. South Atlantic and Gulf of Mexico Continental Shelf. Bull. Mar. Sci. 33:935-940.

Wenner, C. A., W. A. Roumillat, and C. W. Waltz. 1986. Contributions to the life history of black sea bass, *Centropristis striata*, off the southeastern United States. Fish. Bull. U. S. 84: 723-741.